SCOLOPENDRID CENTIPEDES CAUGHT BY PITFALL TRAPPING IN THE ULURU-KATA TJUTA NATIONAL PARK, NORTHERN TERRITORY, INCLUDING A RECORD OF AN APPARENT 'OUTBREAK'

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Pitfall trap surveys of fauna were conducted in the Uluru-Kata Tjuta National Park in 1995, 1997 and 2000. Relatively low numbers of scolopendrid centipedes were trapped during most of the surveys, but heavy summer rainfall in early 2000 may have been responsible for large numbers of individuals trapped then. The surveys have recorded a total of six species of scolopendrid centipedes from the Park, bringing the total known species there to seven.

Key words: Scolopendrid centipedes, Uluru-Kata Tjuta National Park

AUSTRALIAN centipedes are classified into five orders: the Scolopendrida, Geophilida, Lithobiida, Craterostigmatida and Scutigerida (Harvey & Yen 1989). Scolopendrid centipedes are common in the drier regions of Australia. Fortyfour named species of scolopendrid centipedes are known from Australia, and they are predominantly solitary nocturnal predators (Edgecombe 2001) feeding on other invertebrates or occasionally on small vertebrates.

Recent faunal studies of both vertebrates and invertebrates in the Uluru-Kata Tjuta National Park have, under the joint management arrangement at the Park, involved participation by traditional owners (Anangu).

On the morning of 22 February 2000, drift fence pitfall traps that were running as part of a spinifex fire age faunal survey in the Uluru-Kata Tjuta National Park caught enormous numbers of scolopendrid centipedes – a total of 945 individuals in 54 traps (an average of 17.5 centipedes/trap)! The Uluru fauna surveys, conducted in 1995, 1997 and in October 2000, using the same trapping techniques but at different locations within the Park, found relatively small numbers of centipedes. This apparent 'outbreak' in numbers of centipedes was common knowledge amongst the Anangu, who recognise several different colour forms, and had also been reported at the nearby tourist resort at Yulara. However, it had not been recorded in the scientific literature, and this was an opportunity to determine which species of scolopendrid centipedes occurred in the area, and whether particular species had these apparent spectacular increases in numbers.

In this paper we enumerate the scolopendrid centipedes trapped during the spinifex fire age faunal survey in February-March 2000 (SFS) in relation to sites and dates, and will compare results with the three Uluru fauna surveys (UFS) in 1995, 1997 and October 2000.

METHODS

The Uluru fauna surveys were conducted in March-April 1995, September-October 1997 and October 2000. The fauna surveys involved eight sites (Fig. 1), and the same eight sites were sampled in 1995, 1997 and 2000 (Yen *et al.* 1996): UFS 1 (Open grassland to woodland at the base of Uluru), UFS 4 (Mulga shrubland), UFS 5 (Soft spinifex), UFS 6 (Hard spinifex), UFS 7 (Mallee shrubland), UFS 8 (Sandhill mulga), UFS14 (Hard spinifex transitional sandplain), and UFS15 (Alluvial fans and watercourse, Shrubland to River Red Gum creekbed adjacent to Kata-Tjuta). The 2000 spinifex fire-age survey involved six sites (sites 1-6), each of which was divided into three classes of spinifex (older spinifex, younger spinifex, and ecotone). There were two replicates of each spinifex class at each site, resulting in six trap lines within each site. The term "spinifex" is used in this report to describe the various species of hummock grasses found in the study areas. The older spinifex sites (labeled A and B) were last burnt in 1976 or earlier. The younger spinifex sites (E and F) were burnt more recently. In all cases, there was an ecotone between the older and younger spinifex (labeled C and D). The SFS sites are shown in Fig. 1, and the dates on which the pitfall traps were run in 2000 were: SFS 5 (17-20 Feb), SFS 3 (21-24 Feb), SFS 2 (24-27 Feb), SFS 1 (27 Feb – 01 Mar), SFS 4 (01-04 Mar) and SFS 6 (04-07 Mar).

Centipedes were collected by drift fence pitfall trapping. At each site, the pitfall traps were arranged along two intersecting 25 metre lines arranged at right angles to each other, thus forming a cross. The traps were 20 litre buckets. One bucket was located at the intersection of the lines and four additional buckets along each line at six metre intervals. Consequently each pitfall trap site consisted of a set of nine buckets. A nylon drift fence was run along each line to connect the buckets. Within each sampling site, several replicate pitfall lines were operated concurrently. In both the UFSs and the SFS, the same pitfall trap line configuration was used; the only difference was that in the UFS, there were 4 sets of pitfall traps at each site, while in the SFS, there were 6 sets of pitfall traps. The traps were opened for three nights at each site, and examined in the morning and the evening. All invertebrates in the pitfall traps were collected with forceps and preserved in 70% ethanol. All pitfall trap material was eventually identified to the morphospecies level and lodged in the Museum of Victoria.

No attempt will be made in this paper to determine what environmental factors may be important in determining scolopendrid distribution in the UFS and the SFS sites. In the UFS, scolopendrid numbers, both in terms of species and individuals, are in the main low. Superficially, there did not seem to be a consistent trend of scolopendrid association with any of the major plant communities in the UFS. In the SFS, replicates were taken in older and younger spinifex, and ecotones, and the numbers of scolopendrids in these different aged spinifex is considered.

RESULTS

The predominant family of centipedes collected in the pitfall traps was the Scolopendridae. A very small number of centipedes belonging to the Scutigeridae were collected, but they have not been included in this paper. This dominance of the centipede fauna by the Scolopendridae was also found in the Carnarvon Basin of Western Australia (Harvey *et al.* 2000). Unless otherwise stated, results from the UFS and the SFS are presented as number of individuals collected in each site, combining data from each of the pitfall lines. Consequently data from the UFS are based on 4 pitfall lines, while data from the SFS are based on 6 pitfall lines.

Fauna surveys 1995, 1997 and 2000

The numbers of scolopendrids trapped was low in all three surveys (Table 1). Except for two occasions, fewer than 10 individuals were caught in any one pitline in any year. The exceptions were in 1995, when 24 *Ethmostigmus curtipes* were caught in pitline 3 at Site 15 and 20 *E. curtipes* in pitline 4 at Site 15. There was light rain on the night before these were trapped. While these two pitlines were adjacent, they were very different in vegetation: P3 was located in Ti-tree on sand and P4 on River Red Gum creek bed (primarily sand and rock).

In 1995, four species of scolopendrids were trapped, comprising a total of 121 individuals. They were dominated by two species: *Ethmostigmus curtipes* (67.8%) and *Scolopendra morsitans* (27.3%) (Table 1). In 1997, five species (84 individuals) were trapped. *E. curtipes* was again the dominant species, but much reduced in proportion (32.1%); *Scolopendra morsitans* (31.0%) was similar to 1995, while *Cormocephalus* sp. 2 (15.5%), *Cormocephalus* sp. 1 and *E. pachysoma* (10.7% each) occurred in higher proportions (Table 1). In the 2000 UFS, six species (69 individuals) were collected. The percentage compositions were similar to 1997 except that *E. pachysoma* was much reduced: *E. curtipes* (33.3%), *Scolopendra morsitans* (31.9%), *Cormocephalus* sp. 2 (15.9%) and *Cormocephalus* sp. 1 (14.5%) (Table 1).

The occurrence of each of the scolopendrid species thus varied in abundance and distribution over time and space. *Scolopendra morsitans* comprised approximately 33% of the individuals collected in each of the three faunal surveys; it occurred at all eight sites every survey with the exception of UFS 7 in 2000.

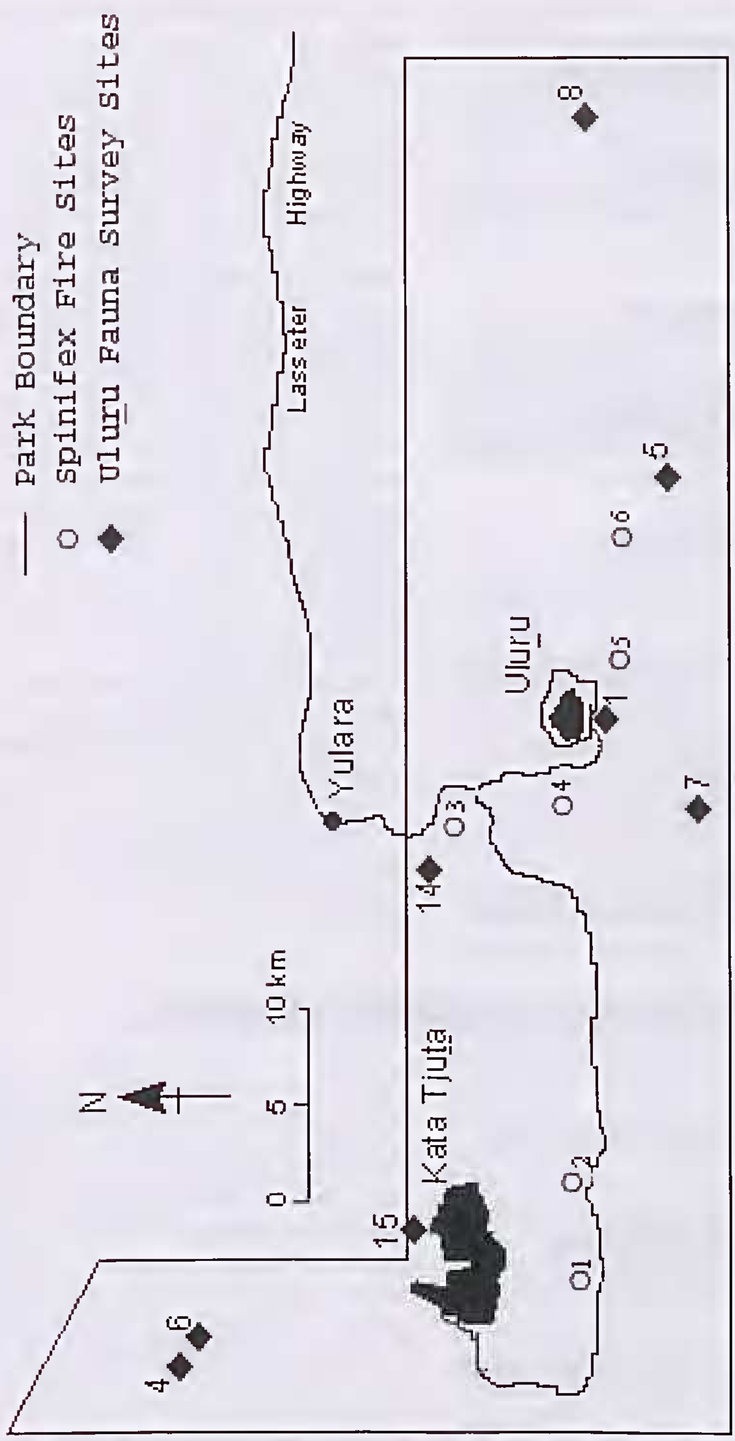

Fig. 1. Map of Uluru-Kata Tjuta National Park showing location of sites

Cormocephalus sp. 1 and 2 were either absent or very low in numbers in 1995, and comprised 10-15% of individuals collected in 1997 and 2000; over the 3 surveys, both species occurred in a total of five out of the eight UFS sites. *E. curtipes* ranged from 33-66% of the individuals trapped, and over the three surveys, was found in all eight UFS sites. In contrast, *E. pachysoma* and *E. rubripes* occurred in low numbers throughout the surveys and were only trapped in 3 of the UFS sites (Table 1).

The number of species trapped at any one site varied from one to five depending upon the year (Table 1). It is worth noting that over the three surveys, all six species were trapped in two sites (UFS7 and UFS8), five species at UFS5, four at UFS15, while only two species were trapped at UFS2 and three species at UFS1, UFS6 and UFS14 (Table 1).

Spinifex fire survey 2000

A total of 6 scolopendrid species, comprising1859 individuals, was collected (Table 2). The fauna, based on percentage composition, was dominated by *E. pachysoma* (53.7%), *E. curtipes* (33.8%) and *Scolopendra morsitans* (11%). These three species were trapped at all six SFS sites, although their abundances, except for *Scolopendra morsitans*, varied between sites. *E. rubripes* was trapped in four of the SFS sites, while *Cormocephalus* sp. 1 and sp. 2 were trapped in three and two sites respectively (Table 2). In terms of relative abundances, *E. curtipes* dominated at four of the six SFS sites (SFS 1, 4, 5 and 6), *E. pachysoma* dominated at SFS3 and *Scolopendra morsitans* dominated at SFS5.

The sudden enormous increase in scolopendrid numbers caught in pitfall traps occurred at SFS3. Pitfall traps were opened at this site on the morning of 21 Feb and closed on the morning of 24 Feb. There was heavy rain on 19 Feb (36.5 mm) and 20 Feb (66.2 mm) before the traps at SFS3 were run (traps were SFS5 were open during the heavy rain). The pitfall traps had large numbers of centipedes on the morning of 22 Feb, followed by fewer on the mornings of Feb 23 and 24. The pitfall trap samples on the morning of 22 February were kept separate from those of the mornings of 23-24 February (when there were fewer centipedes). The data from SFS3 are presented in Table 3. The catch on 22 February was primarily *Ethmostigmus pachysoma*, between 124-180 individuals at each of the six pitfall lines. Small numbers of *E. curtipes* and *Scolopendra morsitans* were trapped on 22 February. The number of *E. curtipes* caught in the traps was larger on 23-24 February, although the number of *E. pachysoma* trapped was marginally higher in three trap lines on these dates. In general, the major occurrence was the enormous increase in *E. pachysoma* numbers on the night of 21 February (and possibly very early in the morning of 22 February), and a sudden drop, although not a disappearance, on the nights of 22 and 23 February.

The SFS was conducted over 20 consecutive days. Considerable rainfall occurred on several days preceding the survey and also during the survey, and it is possible that this rain influenced centipede activity. The abundances of each species of centipede at each of the sites during the SFS are plotted in Fig. 2. *Scolopendra morsitans* was relatively steady in numbers at all sites during the SFS. *Cormocephalus* sp. 1 and sp. 2 occurred in low numbers after Feb 24. The responses of the three *Ethmostigmus* species differed; *E.curtipes* occurred in relatively high numbers throughout the survey, *E. pachysoma* occurred in very high numbers earlier during the survey, while *E. rubripes* occurred in relatively low numbers in four of the six sampling occasions.

The scolopendrid distribution between the different aged spinifex sites is presented in Table 4. More scolopendrids were trapped in older spinifex (A+B), followed by ecotones (C+D) and lowest numbers in younger spinifex (E+F). When examined on a species basis, the major differences in the different spinifex types is due to *Ethmostigmus curtipes*, which seems to prefer older spinifex over younger spinifex (Table 4).

DISCUSSION

There are few previous records of scolopendrid centipedes from the Uluṟu-Kata Tjuṯa National Park. In his revisions of Australian scolopendrids, Koch noted three species from within the Park: *Scolopendra laeta* Haase from Mt Olga and west gorges of Mt Olga (Koch 1982), *Scolopendra morsitans* L. from Mt Olga (Koch 1983a) and *Ethmostigmus rubripes* (Brandt) from Ayers Rock (Koch 1983b). The UFS and the SFS added a further four species of scolopendrid, taking the number of recorded species to seven. Harvey *et al.* (2000) collected 13 species of scolopendrid centipedes by pitfall traps in the Carnarvon Basin of Western Australia, although their study was conducted over a wider geographical region and they ran pitfall traps continuously over a 12 month period.

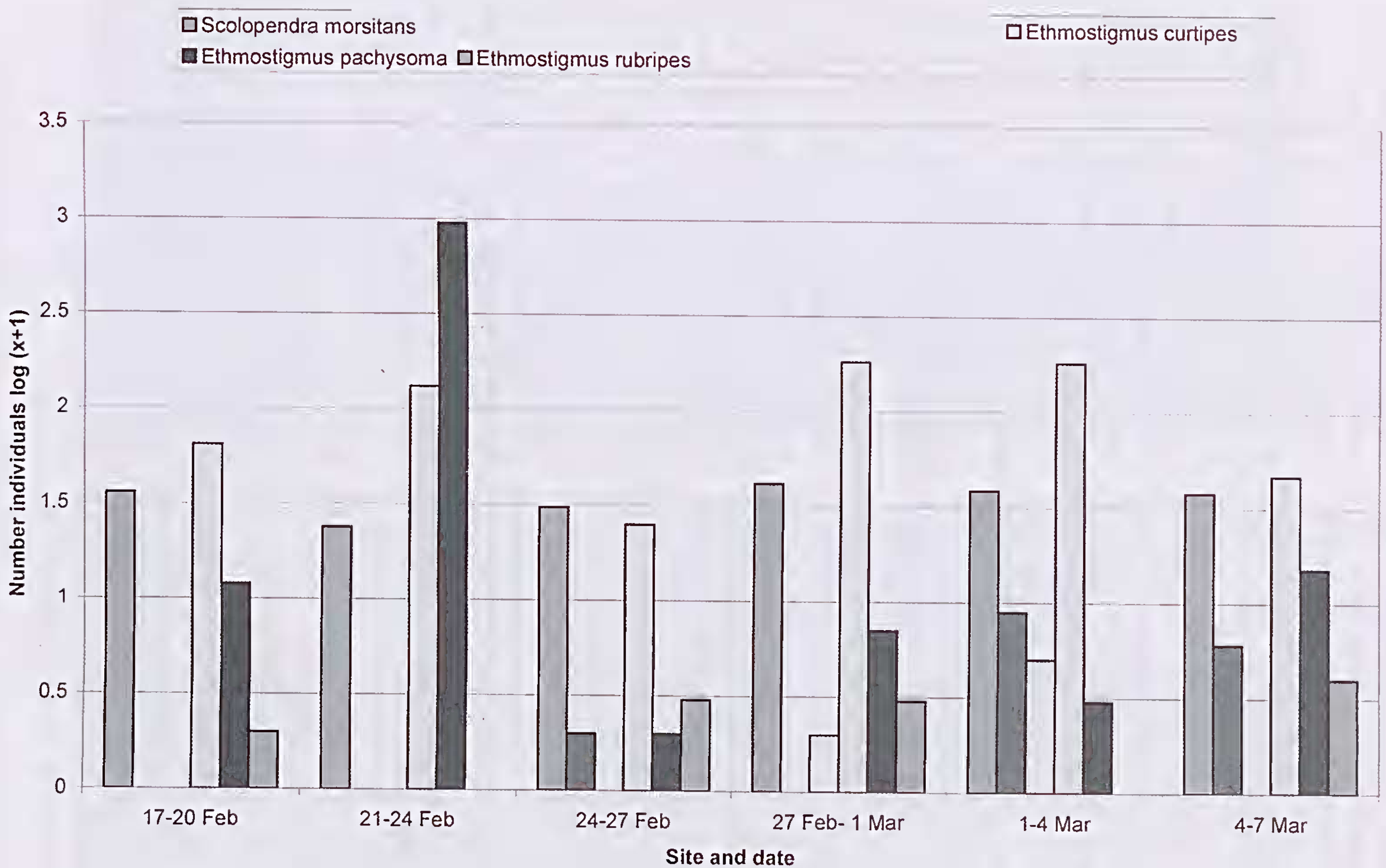

Fig. 2. Centipedes from spinifex fire survey

There are three issues to be discussed with regard to the scolopendrids trapped in the surveys at Uluru-Kata Tjuta. They are (1) the numbers of individuals collected by pitfall trap studies; (2) the response of the scolopendrids to heavy rain; and (3) the role of scolopendrids in the arid systems of Central Australia.

Numbers of individuals and pitfall trapping

In the few published studies on population densities of centipedes, the densities are generally low. The only scolopendrid species studied with regard to density are *Scolopendra amazonica* in Nigeria, which has a density of 0.16/m^2 (and a biomass of 140 mg/m^2), although pitfall trapping was not the collecting method employed (Lewis 1972a). While it is difficult to estimate densities from pitfall trap studies, they can give an indication of whether numbers are low or high. In a fauna survey of the Mallee in north-western Victoria, drift fence pitfall trapping collected centipedes (Robertson *et al.* 1986), and a total of 1026 specimens, comprising 14 species, was collected (Yen & Lillywhite, unpublished data). However, the traps were spread over 122 sites, and each site comprised 10 x 20 litre pitfall traps which were run for five nights on five occasions over an 18 month period, giving an average of less than 2 individuals per pitfall line on each collecting occasion. Corey (1988) used pitfall traps in three plant communities over a six month period (detailed pitfall trap methodology were not given) in Florida (USA), and collected only 28 individuals from 5 species.

Throughout the UFS, the number of scolopendrid centipedes collected in pitfall traps was relatively low. The very large numbers were found at different sites during the SFS during a time of heavy summer rain. However, it appears that during the periods of no or minor rainfall, scolopendrid activity, and consequently catches in pitfall traps are low. The trap records from the Uluru fauna surveys suggest that the densities of scolopendrid centipedes are low.

Response of centipedes to heavy rain

However, the large numbers collected during the SFS suggest that scolopendrid densities may not be as low as suggested by results from the UFS. It is difficult to make definitive conclusions about this because (1) the SFS sites did not coincide with the UFS sites; and (2) it is not possible to distinguish site-specific differences or the effects of heavy rain at the SFS sites because the pitfall traps at each site were run sequentially over time.

In Nigeria, the beginning of the rainy season initiated dispersal of young centipedes (Lewis 1972b). In South-East Asia, responses of two species of scolopendrid centipedes to water differed: *Scolopendra subspinipes* swims when immersed, while *Arrhabdotus octosulcatus* cannot swim and walks under water with its head out of the water. The latter is probably an arboreal species while the former is more likely to experience flooding from tropical down pours (Lewis 1980). Finally, flushing with water has been used as a collecting technique for centipedes (Lewis 1972a).

The results suggest that the increased activity of centipedes, and consequently the larger total numbers trapped, during the SFS is due to heavy rainfall. However, the responses seem to be related to the individual species, especially *Ethmostigmus pachysoma*. The numbers of *Scolopendra morsitans* and *Ethmostigmus curtipes* were steady throughout the SFS, while the numbers of both *Cormocephalus* species and *Ethmostigmus rubripes* remained relatively low. It is suggested that the generally higher rainfall may be responsible for the increased numbers of centipedes caught in the pitfall traps, but the rain may have affected some species more than others. The large numbers of *E. pachysoma* occurred on Feb 21-24 at site SFS3, when the numbers of *Scolopendra morsitans* was lowest and no *Cormocephalus* species or *Ethmostigmus rubripes* were trapped. This may indicate that the last three species did not occur at SFS3, that *E. pachysoma* and *E. curtipes* have higher densities at this site, and the recorded response was due to the heavy rain in the days preceding the trapping. There was even heavier rainfall on 11-13 February, before the SFS began, and it is possible that any response to heavy rain by centipedes may be rapid and short.

Anecdotal information from traditional owners and from visitors to the area indicate previous increased centipede activity after heavy rains. Whether the response is a cue for some aspect of centipede behaviour (dispersal, mate seeking, etc) is not known, although most individuals collected seemed to be mature. Alternatively, the increased activity may simply have been due to centipedes being flushed out of their subterranean habitat.

1995 Uluru fauna survey	S1	S4	S5	S6	S7	S8	S14	S15	Total	%
Scolopendra *morsitans*	4	2	11	2	1	7	4	2	33	27.3
Cormocephalus sp. 1	0	0	4	0	0	0	0	0	4	3.3
Cormocephalus sp. 2	0	0	0	0	0	0	0	0	0	0
Ethmostigmus curtipes	6	5	1	0	0	4	0	66	82	67.8
Ethmostigmus pachysoma	0	0	0	0	0	0	0	0	0	0
Ethmostigmus rubripes	0	0	0	0	1	1	0	0	2	1.7
Total number individuals	10	7	16	2	2	12	4	68	121	
Number species	2	2	3	1	2	3	1	2	4	

1997 Uluru fauna survey	S1	S4	S5	S6	S7	S8	S14	S15	Total	%
Scolopendra morsitans	2	2	6	5	2	2	4	3	26	31
Cormocephalus sp. 1	3	0	4	0	0	0	0	2	9	10.7
Cormocephalus sp. 2	0	0	0	7	1	0	5	0	13	15.5
Ethmostigmus curtipes	4	0	8	3	0	7	5	0	27	32.1
Ethmostigmus pachysoma	0	0	1	0	3	5	0	0	9	10.7
Ethmostigmus rubripes	0	0	0	0	0	0	0	0	0	0
Total number individuals	9	2	19	15	6	14	14	5	84	
Number species	3	1	4	3	3	3	3	2	5	

2000 Uluru fauna survey	S1	S4	S5	S6	S7	S8	S14	S15	Total	%
Scolopendra morsitans	3	3	5	2	0	3	3	3	22	31.9
Cormocephalus sp. 1	1	0	2	0	4	1	0	2	10	14.5
Cormocephalus sp. 2	0	0	3	0	1	2	5	0	11	15.9
Ethmostigmus curtipes	4	0	0	1	3	4	4	7	23	33.3
Ethmostigmus pachysoma	0	0	1	0	0	0	0	0	1	1.4
Ethmostigmus rubripes	0	0	0	0	0	1	0	1	2	2.9
Total number individuals	8	3	11	3	8	11	12	13	69	
Number species	3	1	4	2	3	5	3	4	6	

Table 1. Number of species and individuals of scolopendrid centipedes trapped in the 1995, 1997 and 2000 Uluru fauna surveys

The role of scolopendrids in the arid systems of Central Australia

If we accept that centipede activity is low during times of non-rainfall or light rainfall, and that heavy rainfall flushes out large numbers, then the densities of scolopendrids living in the sand may be much higher than we imagine. Lewis (1981) reported that centipedes can survive aridity by burrowing deep into the soil. A<u>n</u>angu observed centipede burrows in the sand at Ulu<u>r</u>u. The question arises as to whether they form structured burrows or whether they simply 'swim' in sand. Other interesting topics include how frequently they emerge above ground, and whether they catch food in their subterranean habitat. *Scolopendra* and *Cormocephalus* are solitary species (Lewis 1981).

It is interesting to speculate upon the ecological role that centipedes play in the semi-arid and arid zones of Australia. Intraspecific encounters are usually aggressive (Edgecombe 2001). They are relatively large predators (in invertebrate terms), and as such would be expected to play a significant role in view of the large numbers trapped during the SFS. A wide variation in the diets of scolopendrids has been recorded from around the world; food ranges from invertebrates to small vertebrates (Lewis 1981). There is an abundance of potential invertebrate food for centipedes in Central Australia. The ground-active invertebrate fauna is dominated by ants and termites, and A<u>n</u>angu report that during dry conditions, centipedes catch ants as food. After rain, they emerge to catch termites. In turn, their relatively large body size would provide a decent meal for higher level predators, and A<u>n</u>angu report that they are eaten by sand goannas.

In the western desert region of Australia, centipedes are called 'wanatji<u>t</u>i' or 'kanparka' in the Pitjantjatjara language. According to the traditional owners (A<u>n</u>angu), there is Tjukurpa (Law) associated with centipedes; and some of this information is not available.

Much remains unknown about scolopendrid centipedes. Their basic life histories and longevity remains to be determined. Population numbers and fluctuations and habitat factors that influence their distribution are still unknown.

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	SFS1	SFS2	SFS3	SFS4	SFS5	SFS6	Total	%
Scolopendra morsitans	41	30	23	38	35	37	204	11
Cormocephalus sp. 1	0	1	0	8	0	5	14	0.8
Cormocephalus sp. 2	1	0	0	4	0	0	5	0.3
Ethmostigmus curtipes	183	24	131	181	64	46	629	33.8
Ethmostigmus pachysoma	6	1	965	2	11	14	999	53.7
Ethmostigmus rubripes	2	2	0	0	1	3	8	0.4
Total number individuals	233	58	1119	233	111	105	1859	
Number species	5	5	3	5	4	5	6	

Table 2. Number of species and individuals of scolopendrid centipedes trapped during spinifex fire age survey Feb-March 2000

assistance with identification of the centipedes, and Leigh Ahern for field assistance during the 2000 UFS. The work was conducted with financial support from Environment Australia, and we are indebted to Jake Gillen and Sam Rando for their organization of the project. Various staff members of Parks Australia North assisted with various aspects of these surveys, and traditional owners (Imantura, Daisey Walkabout, Joyce Tjalyiri, Ginger Tjintalka and Billywara) also provided support and information.

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	Site 3A		Site 3B		Site 3C		Site 3D		Site 3E		Site 3F	
	22-Feb	23/24 Feb	22-Feb	23/24 Feb	22-Feb	23/24 Feb	22-Feb	23/24 Feb	22-Feb	23/24 Feb	22-Feb	23/24 Feb
Scolopendra morsitans	1	0	2	5	3	1	2	1	1	1	3	3
Ethmostigmus curtipes	8	36	16	31	4	15	1	0	4	8	1	7
Ethmostigmus pachysoma	166	22	180	5	124	7	144	11	151	10	134	10

Table 3. Pitfall trap catches of scolopendrids at site 3 during 'outbreak' in February 2000. he traps were opened on 21 Feb and closed on 24 Feb.

SFS Site and date	Species	Old	Ecotone	Young
Site 1. 27 Feb - 01 Mar 2000	*Scolopendra morsitans*	13	20	8
	Cormocephalus sp. 1	0	0	0
	Cormocephalus sp. 2	1	0	0
	Ethmostigmus curtipes	92	72	19
	Ethmostigmus pachysoma	3	2	1
	Ethmostigmus rubripes	0	1	1
	Total	109	95	29
Site 2. 24-27 Feb 2000	*Scolopendra morsitans*	4	14	12
	Cormocephalus sp. 1	0	0	1
	Cormocephalus sp. 2	0	0	0
	Ethmostigmus curtipes	9	8	7
	Ethmostigmus pachysoma	0	0	1
	Ethmostigmus rubripes	0	1	1
	Total	13	23	22
Site 3. 21-24 Feb 2000	*Scolopendra morsitans*	8	7	8
	Cormocephalus sp. 1	0	0	0
	Cormocephalus sp. 2	0	0	0
	Ethmostigmus curtipes	91	20	20
	Ethmostigmus pachysoma	373	287	305
	Ethmostigmus rubripes	0	0	0
	Total	472	314	333
Site 4. 01-04 Mar 2000	*Scolopendra morsitans*	9	15	14
	Cormocephalus sp. 1	5	1	2
	Cormocephalus sp. 2	1	0	3
	Ethmostigmus curtipes	106	33	42
	Ethmostigmus pachysoma	1	0	1
	Ethmostigmus rubripes	0	0	0
	Total	122	49	62
Site 5. 17-20 Feb 2000	*Scolopendra morsitans*	16	10	9
	Cormocephalus sp. 1	0	0	0
	Cormocephalus sp. 2	0	0	0
	Ethmostigmus curtipes	13	45	6
	Ethmostigmus pachysoma	6	1	4
	Ethmostigmus rubripes	0	0	1
	Total	35	56	20
Site 6. 04-07 Mar 2000	*Scolopendra morsitans*	18	15	4
	Cormocephalus sp. 1	4	0	1
	Cormocephalus sp. 2	0	0	0
	Ethmostigmus curtipes	21	24	1
	Ethmostigmus pachysoma	2	9	3
	Ethmostigmus rubripes	0	1	2
	Total	45	49	11
	Total	45	49	11
Total for all sites	*Scolopendra morsitans*	68	81	55
	Cormocephalus sp. 1	9	1	4
	Cormocephalus sp. 2	2	0	4
	Ethmostigmus curtipes	332	202	95
	Ethmostigmus pachysoma	385	299	315
	Ethmostigmus rubripes	0	3	5
	Total	796	586	478

Table 4. Differences between old, ecotone and young spinifex sites

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